of cirrostratus cloud, had considerable resemblance to auroral beams faintly visible in the twilight; a considerable extension of the twilight-glow towards the north-west also suggested the very possible character of their light. Towards nine o'clock Mars rose redly through a considerable haze in the east, and Venus, in full splendour, appeared setting among slight clouds in the west; the planet Jupiter, and all stars above a slight distance from the horizon, were altogether unobscured by clouds. A pretty bright white auroral arch, divided into low streamers, was at this time first distinctly formed, its lower edge being well marked by their bases, and the brightest streamers being clustered in two knots of the arch, in the middle of Cassiopeia, and of Lyra, the first immediately under Polaris, and the other close to the north-east horizon; the western prolongation of the arch was faint and diffuse, shining from behind and among the clouds around the planet Venus. Tall but faint streamers rose from it, none of which were conspicuous, excepting a pretty well defined one rising at $9^h\ 5^m$ from the strongly luminous light-cloud in Lyra, nearly to the tail-stars of Ursa Major. This beam grew sharper, and in the following minute it passed across σ Herculis, and ϵ Ursæ Majoris, but it shortly disappeared. Between $9^h\ 8^m$ and $9^h\ 12^m$ the two principal light-clouds in Cassiopeia and Lyra increased in strength, assuming with the contiguous part of the arch a perfect resemblance to the heavy fringe of a curtain gathered or folded upon itself at those points, and particularly in the group of streamers under α Lyræ. At $9^h\ 12^m$ another luminous patch marked the western end of the arch between Venus and Capella, growing brighter, and from it a bunch of rose-coloured streamers sprang upwards between Auriga and Gemini as far as the forefoot of Ursa Major. At $9^h\ 15^m$, the bright cloud-mass marking the eastern horizon-point of the arch under α Lyræ also acquired great strength, throwing up a torch-like, fire-coloured streamer of moderate height and great brightness, terminating the arch abruptly in that direction. It rose from the horizon across o, χ to π, ρ, Herculis. A fainter arch underneath the former one was visible at this time, but less well-defined, and streamers rising from both arches, and mingling together, soon quite overspread the northern sky; a bunch of these streamers of rich crimson colour appeared at $9^h\ 18^m$, extending for a short time across o, θ, and other neighbouring stars of Ursa Major, and fading gradually away, disappeared almost as quickly as it came. The number and sharpness as well as the height of the streamers rising from both the arches were now very great, and the light from all the surrounding streamers was so strong that I could read my watch and correct notes in my note-book at this time. A fourth bunch of red streamers rose from the arch at its extreme west end at $9^h\ 23^m$ from the neighbourhood of α Orionis to the stars γ, ν, in the feet of Gemini. This was the last strikingly red streamer seen during the display; its spectrum, like that of the white beams, which I examined with a small pocket spectroscope, appeared to consist only of the usual bright greenish line, which was very vivid in every phase of the aurora.

At $9^h\ 25^m$, the whole northern half of the sky was covered with streamers, and arches, gradually forming a corona overhead, and increasing rapidly to great intensity and brightness. The boundary of the light from east to west was a definite line passing through, or very little south of the corona, whose centre was 3° or 4° east from the stars ν, χ in Ursa Major. Northwards from the boundary line the aurora consisted of six or seven parallel arches (of which only the lowest two had before been visible), more or less distinctly succeeding each other between the zenith and the horizon. Both the arches and streamers were stationary, and presented no sensible tendency to motion, however slow, while they were visible. At this time the brightening streamers began to flicker in their light. Waves of light, rising from the north, succeeded each other rapidly, and appeared to flow swiftly over them towards the zenith. Arch after arch was visible as the waves passed over them, and fitful gleams among the auroral masses overhead shot to and fro there, like flashes of summer lightning. The rays and wisps of the corona, and belts, or fragments of the aurora overhead were rendered especially luminous by these discharges. Farther from the zenith, in the north, the waves rose smoothly and steadily, with a motion that was indeed very swift, but it was yet quite distinctly discernible, and more easily distinguishable there, than in their passage overhead. The arches, or belts of the streamers appeared to be lighted up instantaneously, as they were reached. Although their inter-mixture in the north made it very difficult to decide this clearly, yet the upward progress of the waves there was very evident, while no such ascending movements could be distinguished in the east and west quarters of the sky. The belts and arches stretching towards those parts of the horizon, through the zenith, and past, or through the corona, forming the termination of the aurora towards the south, were constantly lighted up by momentary flashes, extending almost simultaneously along their whole lengths. The brightness of the flashes in those parts of the aurora which included the corona, and arches or lateral branches extending from it towards the magnetic east and west points is easily accounted for by the belts and clusters of streamers in those positions being seen "on edge," or "end on," extremely foreshortened by perspective, so that the increase of light along their whole heights appeared to be concentrated, when the waves overtook them, to a single flash. The motion of the waves must be extremely swift, as they scarcely occupied more than a second in passing from an altitude of about 45° to the zenith. Supposing that (as the best observations of them have frequently agreed in showing) the heights of auroral arches, and of the bases of auroral streamers, are usually about 100 miles above the earth's surface, the velocity of propagation of these waves of electrical disturbance from north to south cannot have been much less than 100 miles per second. Such a prodigious velocity cannot possibly be ascribed to waves in the upper atmosphere driven by winds among its rarified strata, to which the sweeping motion of the light waves apparently wafted by gusts among the streamers otherwise bore a very singular resemblance.

At $9^h\ 34^m$ some of the strongest waves passing across the corona lighted up a faint white arch in the south, extending from Arcturus across the northern part of Virgo to the head of Leo, several degrees in width. At $9^h\ 37^m$, when the wave disturbance, after continuing in full activity for about ten minutes, ceased as rapidly as it began, this arch and the corona still remained faintly visible; but together with all the other arches and streamers of any altitude lately lighted up by the waves, they soon vanished, and the whole appearance of the sky at $9^h\ 40^m$ was about the same as when the aurora was first seen. At $9^h\ 43^m$, however, the northern sky was again crowded in every part with thin white streamers scattered indiscriminately over it, like groves of slender fir-trees on a hillside, among which one very sharp and bright ray shone for a few seconds, springing from the horizon to a considerable altitude in the west, where it passed across ζ Tauri. At $9^h\ 50^m$ a streamer, starting from a base of intense whiteness near the same place, and tinged at the top with a pinkish hue, ascended across the stars μ, ν, as far as the star ι in Gemini, another very similar streamer almost simultaneous with it, also extended from between Gemini and Auriga to near the forefoot of Ursa Major; a few spots of very intense white light were at the same time visible here and there among the low clouds near the north-west horizon. At $9^h\ 55^m$ all conspicuous streamers had disappeared, leaving only a general glow, among the brighter parts of which the wave disturbance began again, and with less intensity than before, but with the same regularly ascending motions; the undulations succeeded each other without intermission until $10^h\ 5^m$; they then ceased, and the faint appearances of the aurora which were visible after this time were, so far as I could observe them, until half-past eleven o'clock, of a very insignificant and inconspicuous character. The times in this description are from a comparison of my watch with the clock in the Carlisle railway station, and its hand and the figures on its dial being always distinctly visible by the light of the aurora, they have probably been recorded rightly to the nearest minute. Although the dates of the April meteoric shower usually occurring on the nights of the 19th —21st of April are near at hand, I saw but one small shooting-star during the hour of the auroral exhibition. It had a short course in one of the brightest parts of an auroral cloud, and in its light and the aspect of its nucleus it did not appear to be affected in any way remarkably by its passage near or underneath the beams of the aurora.

A. S. HERSCHEL

Carlisle, April 18

April Meteors

DURING the evenings of April 19 (9^h to 11^h) and 20th ($8^h\ 45^m$ to $11^h\ 15^m$) 20 shooting stars were observed here. The sky was cloudless on both nights, and on the 18th and 19th bright displays of auroræ were noticed. Of the 20 meteors 12 were well observed, and their tracks accurately marked; 8 of

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these radiated from near *α* Lyræ, or from a point at R. A. 274°, D. 37 +. The following are the details :—

Date.	Time.		Beginning.		Ending.	
			R. A.	D.	R. A.	D.
April 19	9.28	1st mag. *	295°½	46°+	316°	51°+
,,	10.31	2nd mag. *	305	38 +	309	37½+
,,	10.43	3rd mag. *	277	36½+	278½	35 +
,,	10.50	4th mag. *	256½	17 +	254	13 +
April 20	9 10	3rd mag. *	266	17 +	264½	13 +
,,	9 50	3rd mag. *	319	45 +	329	45 +
,,	11.4	2nd mag. *	282	22 +	285	16 +
,,	11.13	2nd mag. *	264½	16 +	261½	9 +

The other four showed a well-marked radiant point at R. A. 221°½, D. 20 + in Bootes. The observed paths of these were as under :—

Date.	Time.		Beginning.		Ending.	
			R. A.	D.	R. A.	D.
April 19	9.58	2nd mag. *	307°½	43°+	285°	33°+
April 20	9.9	3rd mag. *	247	28 +	258	29 +
,,	9 54	1½ mag. *	244	53 +	268	67 +
,,	10.55	1st mag. *	225	19 +	246	16 +

The brightest meteor seen was one that appeared at $9^h 28^m$ on April 20. It diverged from the radiant in Lyra, and was about equal in brilliancy to *α* in that constellation This meteor left a train which remained visible about 1½ sec. after the disappearance of the head.

Bristol, April 21 WILLIAM F. DENNING

I SEND the following observations of the shooting stars of the April period, viz., the 19th and 20th. On the 19th I began to watch at 10^h, but saw no more until 11 45. I then watched them until $3^h 15^m$. I found they seemed to come in the region of the heavens about Corona, so I confined my observations to that part as I had not a situation where I could see the opposite side as well By 10 o'clock Hercules was quite above the buildings, so there may have been some meteors visible earlier, when these constellations were too low for me to see. The first night they were all comprised in a triangle, which would be formed by a line stretching from Vega by way of Ophiuchus to Mars, and thence up to Arcturus and by Corona back to Vega. They were pretty equally distributed over this region. The next night they were much more concentrated in Ophiuchus and Hercules and towards Libra. I was not able to determine the radiant, so I confined myself to reckoning them accurately in intervals of fifteen minutes, which time I had conveniently marked for me by the church clocks, and only observed their tracks approximately. On the second night I noted the position and direction of each which shows their concentration about the part named. On the nineteenth there were 25—15 horizontal, 10 vertical. On the 20th from 9.45 to 2.45 there were 33—22 vertical and 11 horizontal. Those I call vertical by distinction were almost all just half way between horizontal and vertical, *i.e.* at an angle of 45°. It was curious how this angle predominated. It was also curious that the first night the horizontal ones predominated, and the second night the vertical. I do not know if I am wrong (1) in assuming that we pass through the node of the orbit of the meteors at this time, and (2) in inferring from this assumption that the angle at which they principally appear to us would be a guide to the inclination of the node. Would the fact of their being horizontal be any proof that the inclination of their orbit is small, and their being vertical a proof that it is much greater, and of a somewhat similar angle? But this would not explain the fact of the majority being horizontal the first night and the majority at a greater angle the next night. One seen on the 20th was intermittent, it ran for a long distance, and became visible at intervals of a few seconds a little way further on. Only a few were of any size, and the first night all but two were extremely small and very faint, with very short tracks. The next night they were not only greater in number but larger, brighter, and with longer tracks. A few left tracks lasting a second or two. One only moved very fast. The first night there was one quite vertical *upwards*. This was the only instance. The majority were from E. to S. or E. to W. on both nights; and the only two of any length on the 19th were one running out of Corona and one running into it. It seemed curious to me how these should be so much longer than all the others and yet lie so close to the point of apparent divergence of them all. The following is a list for the two nights of the number in each 15 minutes: April 19.—From 11.45 to 12, 2; 12.15, 5; 12.30, 2; 12 45, 2; 13, 1; 13.15, 5; 13.30, 1; 13.45, 0; 14, 3; 14.15, 2; 14.30, 0; 14.45, 1; 15, 1; 15 to 15.30, 0; Total: 25.

April 20.—From 9.45 to 10, 1; 10.15, 3; 10.30, 1; 10.45, 0; 11, 5; 11.15, 2; 11.30, 2; 11.45, 1; 12, 0; 12.15, 1; 12.30, 1; 12 45, 1; 13, 2; 13.15, 4; 13.30, 2; 13.45, 2; 13.45 to 14.30 0; 14.45, 5; Total: 33. P. B.

Bath

Instinct

A Mechanical Analogy

MR. DARWIN, in his article on "The Origin of certain Instincts," in NATURE, of April 3, appears inclined to think that what we may call the instinct of direction in animals is of the same kind as the faculty by which men find their way: and he instances the power of the natives of Siberia to find their way over hummocky ice. He afterwards, however, raises without discussing the question "whether animals may not possess the faculty of keeping a dead reckoning of their course in a much more perfect degree than man, or whether this faculty may not come into play on the commencement of a journey when an animal is shut up in a basket." I wish to point out that this peculiar power of animals is one that cannot be explained as a higher degree of any power that man possesses. What man can do is to find the third side of a triangle after travelling the other two sides *with his eyes open*. Animals can do the same after travelling the two sides *with their eyes shut*. The former power does not in any degree involve the latter. Moreover, the power of man here spoken of depends on the careful use of his powers of observation. This does not appear to be the case with animals. Among the many instances of animals finding their way home after being conveyed away without any opportunity of seeing their way or taking their bearings, there must in all probability be many in which the animal slept on the journey: and if so, the mental or organic process whereby it was able to know its way back must have gone on during sleep. There is nothing in man's mind similar to such a process as this. It can be made conceivable only by a mechanical analogy, if at all.

If a ball is freely suspended from the roof of a railway carriage, it will receive a shock sufficient to move it, when the carriage is set in motion: and the magnitude and direction of the shock thus given to the ball will depend on the magnitude and direction of the force with which the carriage begins to move. While the carriage is in uniform motion the ball will be relatively at rest; and every change in the velocity of the motion of the carriage, and of its direction, will give a shock of corresponding magnitude and direction to the ball. Now, it is conceivably quite possible, though such delicacy of mechanism is not to be hoped for, that a machine should be constructed, in connection with a chronometer, for registering the magnitude and direction of all these shocks, with the time at which each occurred; and from these data—the direction of the shock indicating the direction of the motion of the carriage, the magnitude of the shock indicating its velocity, and the interval of time between two shocks indicating the time during which the carriage has run without change of velocity or direction—from these data the position of the carriage, expressed in terms of distance and direction from the place from which it had set out, might be calculated at any moment. The automatic register of the journey may be conceived as exactly resembling the records of the velocity and direction of the wind produced by one of Robinson's or Beck's self-registering anemometers, where one pencil-mark indicates the direction of the wind, at any past hour, and another its velocity.

Further, it is possible to conceive the apparatus as so integrating its results as to enable the distance and direction of the point where the journey began to the point it has reached, that they can be read off, without any calculation being needed:—a hand on a dial pointing to the direction expressed in degrees of the circle, and the distance being shown in figures expressing miles and decimals of a mile.

Now, I suppose such an integrating process as this (though of course not by any similar mechanism) to be effected in the brain of an animal unconsciously, and that the animal has the power of reading off the result—that is to say, bringing it into consciousness when wanted. JOSEPH JOHN MURPHY

Old Forge, Dunmurry, co. Antrim, April 11

Sense of Orientation

YOUR article on this subject in the issue of March 20, insists very properly on the objection to Mr. Wallace's theory that "if it be solely by the aid of this memory of smells that the dog is

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